

People, Partners, Performance: Incident Surveillance To Change The Electrical Safety Culture

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Outline

- Introduction
- Background
- Methods
- Data Collection, Templates & Analysis
- Key Insights
- Closing

Introduction

Reasons for Research

- ...to find education and communication strategies advancing more effective prevention.
- ...to improve treatment for those who survive electrical injury from current or lightning.
- ...to reduce disability in electrical injury survivors.

Core Beliefs

- No person should be killed, injured or sickened doing their work.
- The environment is precious and should be protected.
- Safety must never be left to chance.

Common Events

- Daily in workplaces throughout the country, seemingly intelligent, capable, and accomplished individuals commit acts that coworkers and bosses pause and marvel over, asking
“How could s/he do that?”

When an act creates loss...
its significance escalates.

What does it take...

to make a mistake on the job?

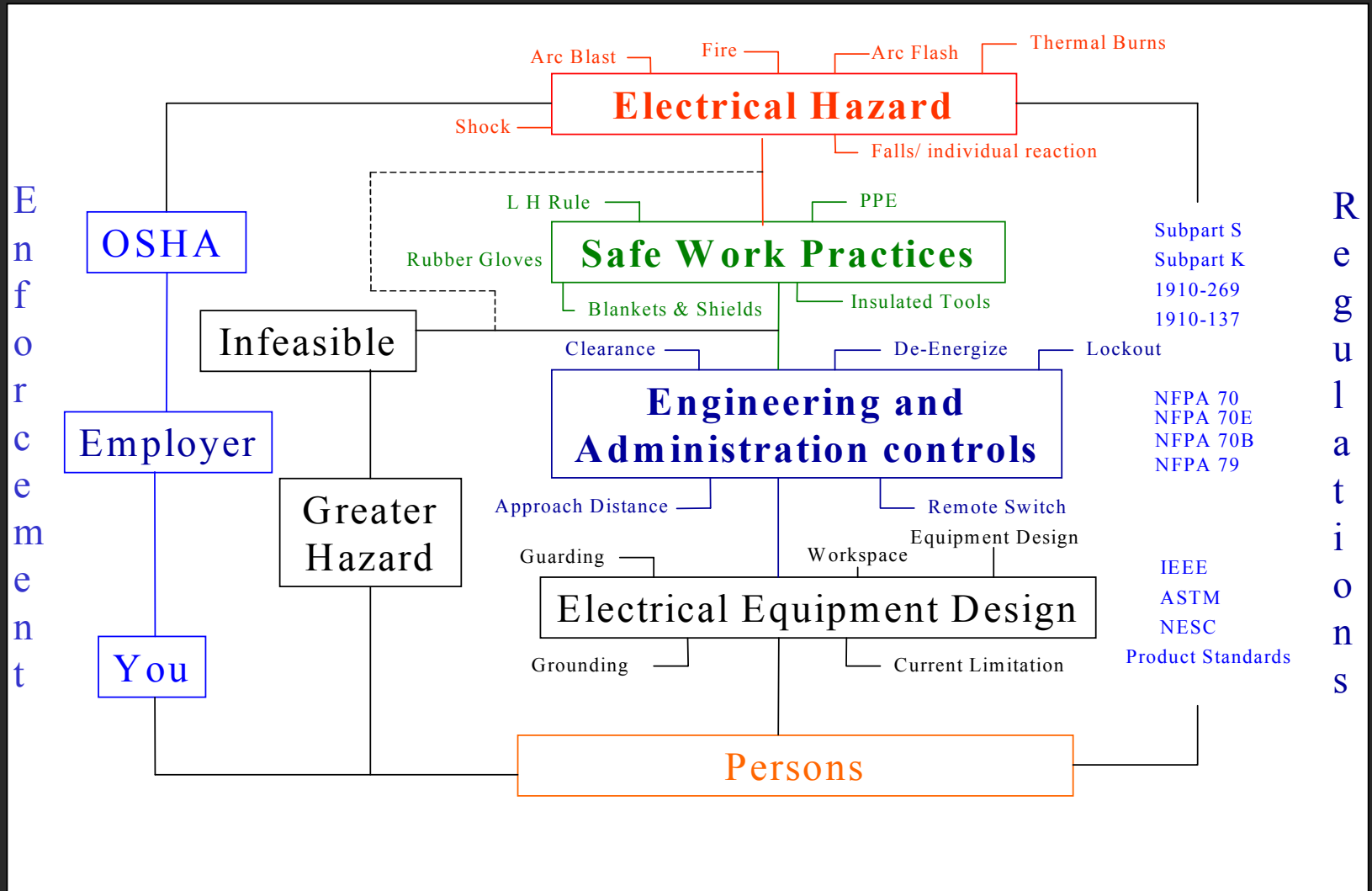
Changing Our Focus...

- Past: The explanation for an incident lies in how an employee has acted...
- Present: The explanation for an incident lies in the information an employee has before he acted...
- Future: The explanation for an incident lies in the decisions which create information...

Information is power.

Decisions creating information
are embedded in processes.

Electrical Safety Processes



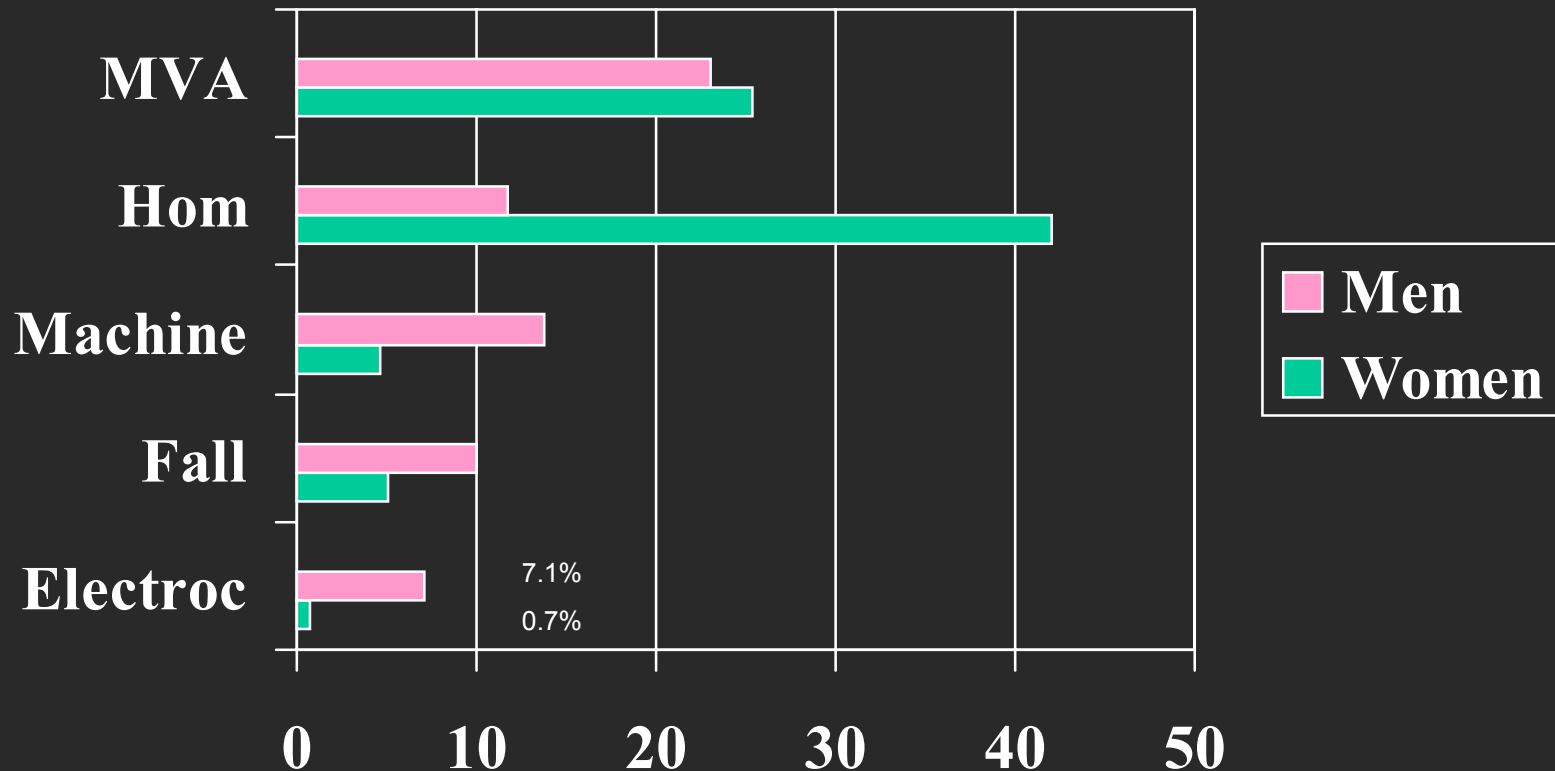
Ref: Callanan M, et al. *Applied Fundamentals for Integrating Electrical Codes and Standards*, in review.

Background

Distribution of fatal occupational injuries for male and female workers by selected cause of death, 1980-1995.

Total deaths: Male - 87,835; Female -6,088.

Source: NTOF [1999].



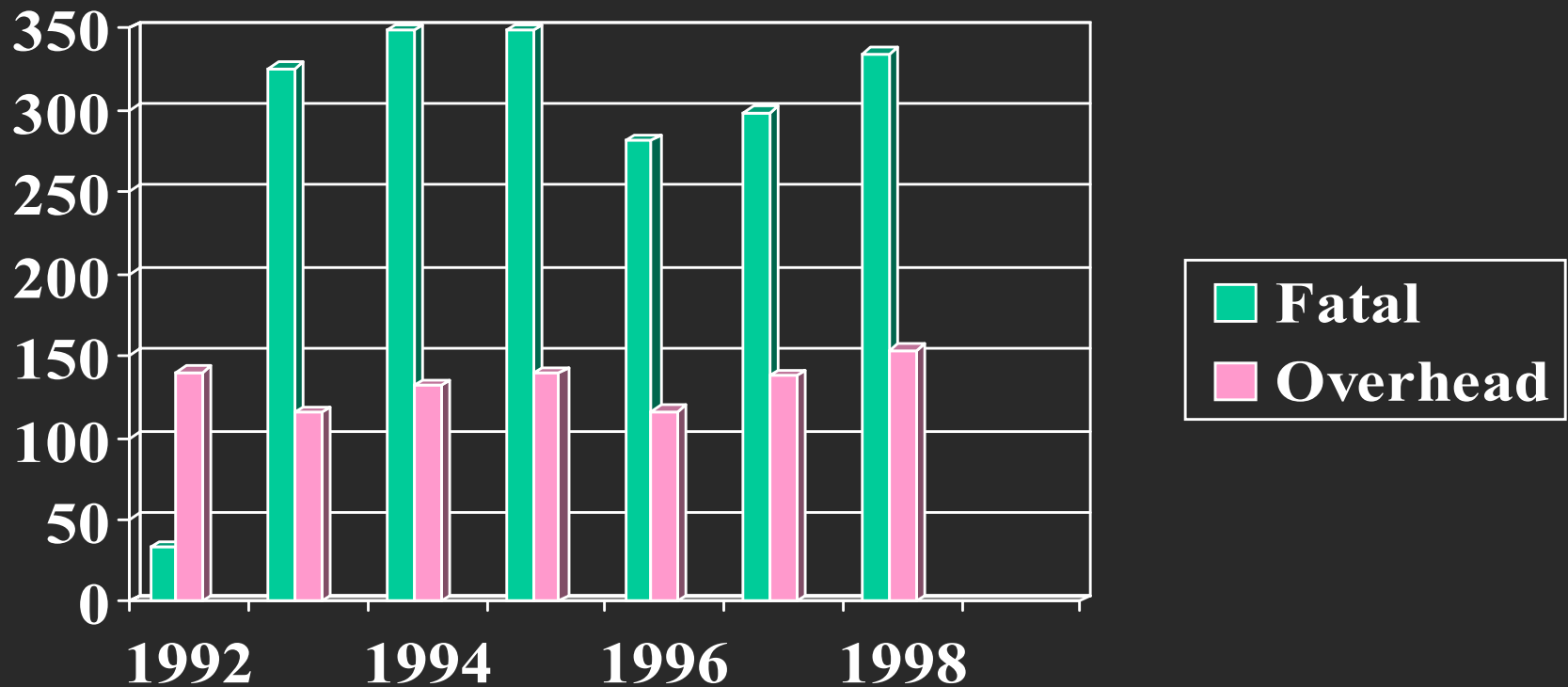
Fatal Electrical Injuries

All Industries (1992 – 1998)

Fatal electrical injuries = 2,268.

Total fatalities from overhead power lines = 933.

Source: BLS – CFOI, SOII, 1992 - 1998



Ref: Homce GT, Cawley JC, et al. An Alarm to warn of overhead power line contact by mobile equipment.

Proceedings of IEEE IAS Annual Meeting, Chicago, 2001.

Nonfatal Electrical Injuries

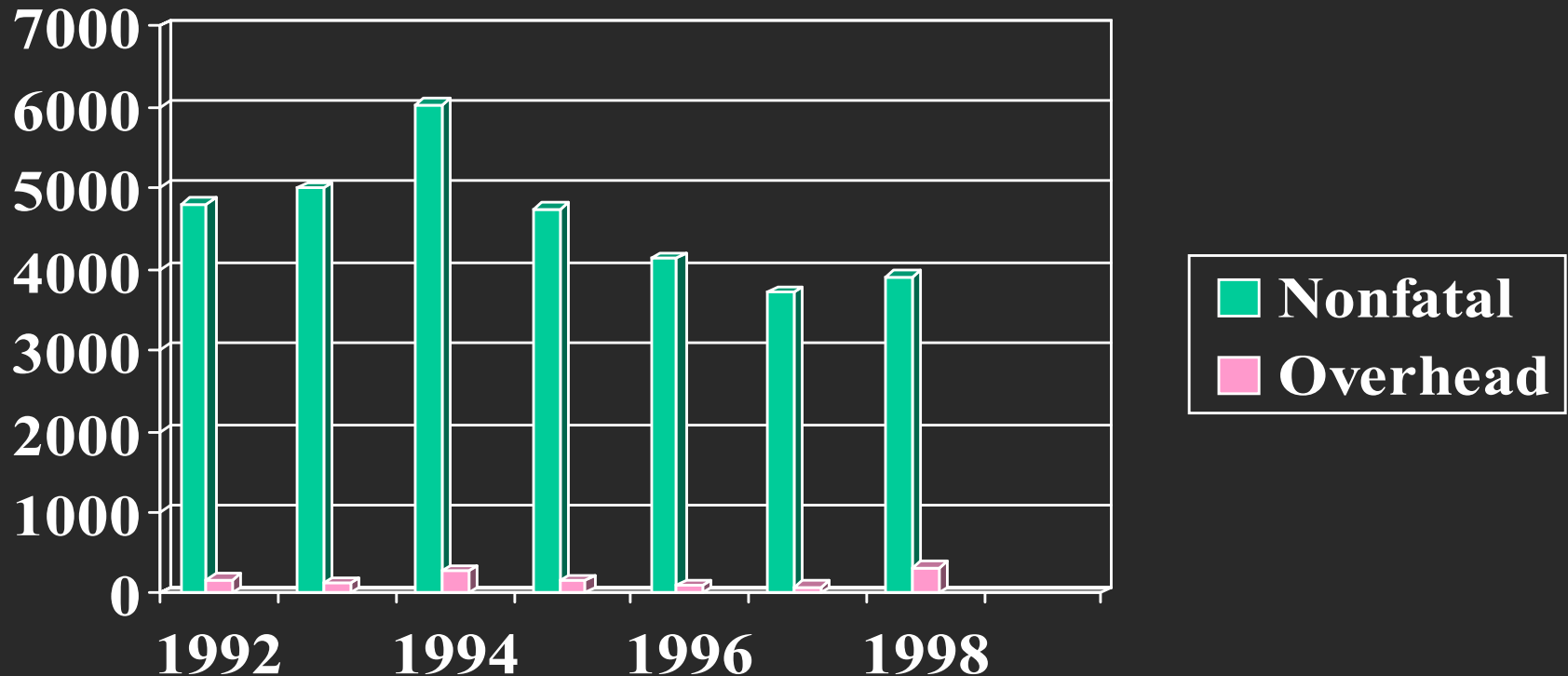
All Industries (1992-1998)

Nonfatal electrical injuries involving days away from work.

Total nonfatal electrical injuries = 32,309.

Total electrical injuries from overhead power lines = 1,220.

Source: BLS – CFOI, SOII, 1992 - 1998



Ref: Homce GT, Cawley JC, et al. An Alarm to warn of overhead power line contact by mobile equipment. Proceedings of IEEE IAS Annual Conference, Chicago, 2001.

NIOSH Study: Electrical Accidents in Mining Industry, 1990-1999

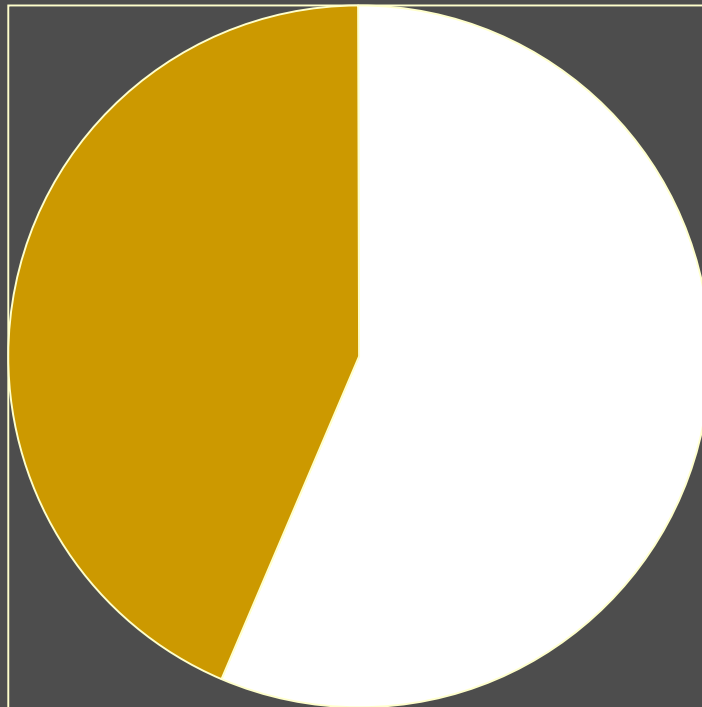
- Electrical shock – 70 of 75 mining electrical fatalities
- Electricity 4th leading cause of reported death in mining accounting for 3.89% fatalities
 - 1990s – 1 of every 272 mining accidents resulted in fatality
 - 1990s – 1 of every 26 mine electrical accidents resulted in
- Electrical source - 14th cause of mining injury
- Maintenance activities – Accounted for ~50% electrical accidents and fatalities
- Case studies – 20% indicated overhead lines

Ref: Cawley JC. Electrical accidents in the mining industry, 1990 – 1999. In the Proceedings of the IEEE IAS Annual Conference, Chicago, 2001.

Construction

Electrical Fatalities Statistics

1999 Electrical Current (278)
Fires & Explosions (216)

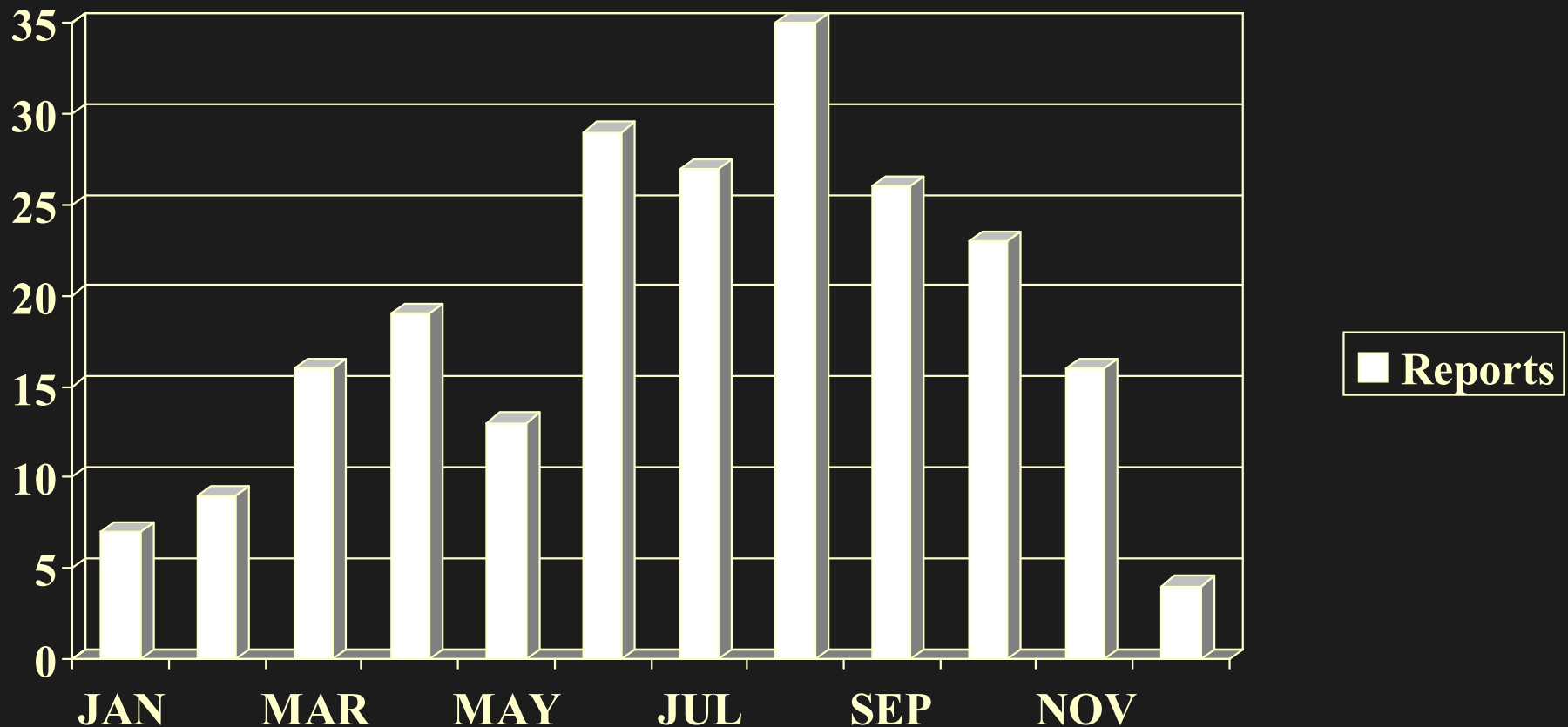


■ Elec Current
■ Fires/Expl

In 1999---
1-2 fatalities/day
Caused by
Electrical Current,
Fires & Explosions

Electrocution Fatalities By FACE

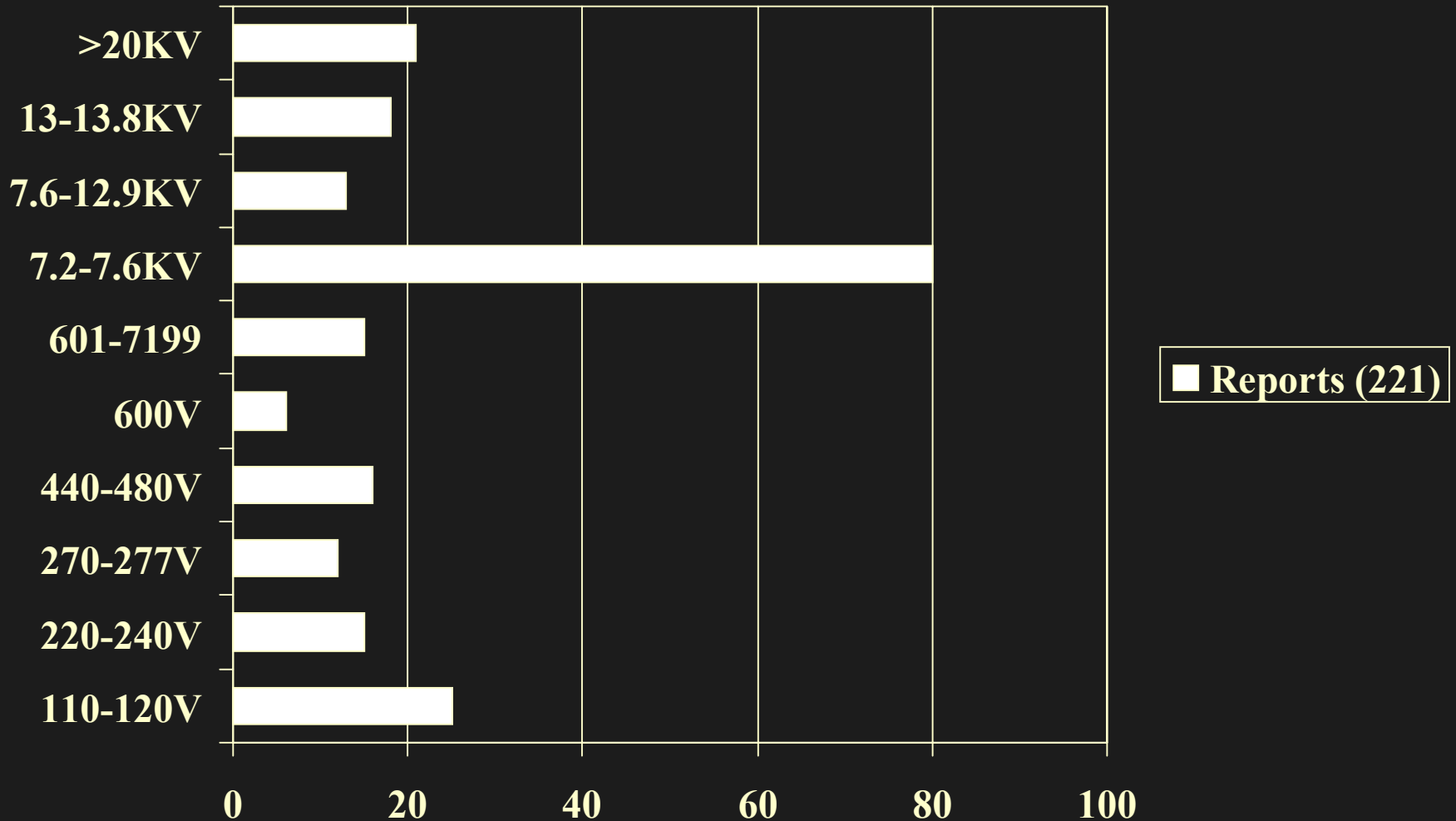
By Month, 1982-1994



Ref: NIOSH. Worker Death by Electrocution: A Summary of NIOSH Surveillance and Investigative Findings, 1998, Figure 8, p. 16

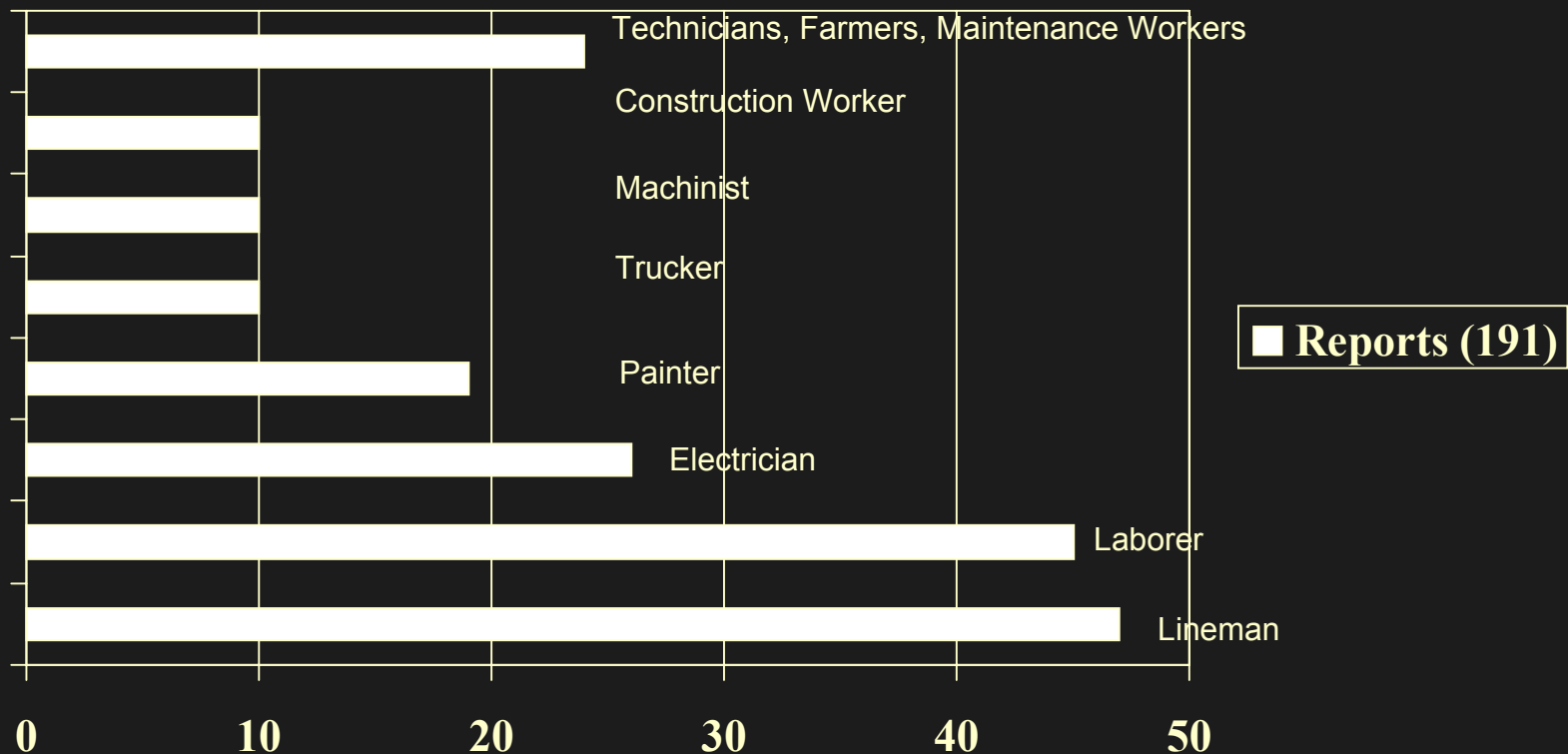
Electrocution Fatalities By FACE

By Voltage, 1982-1994



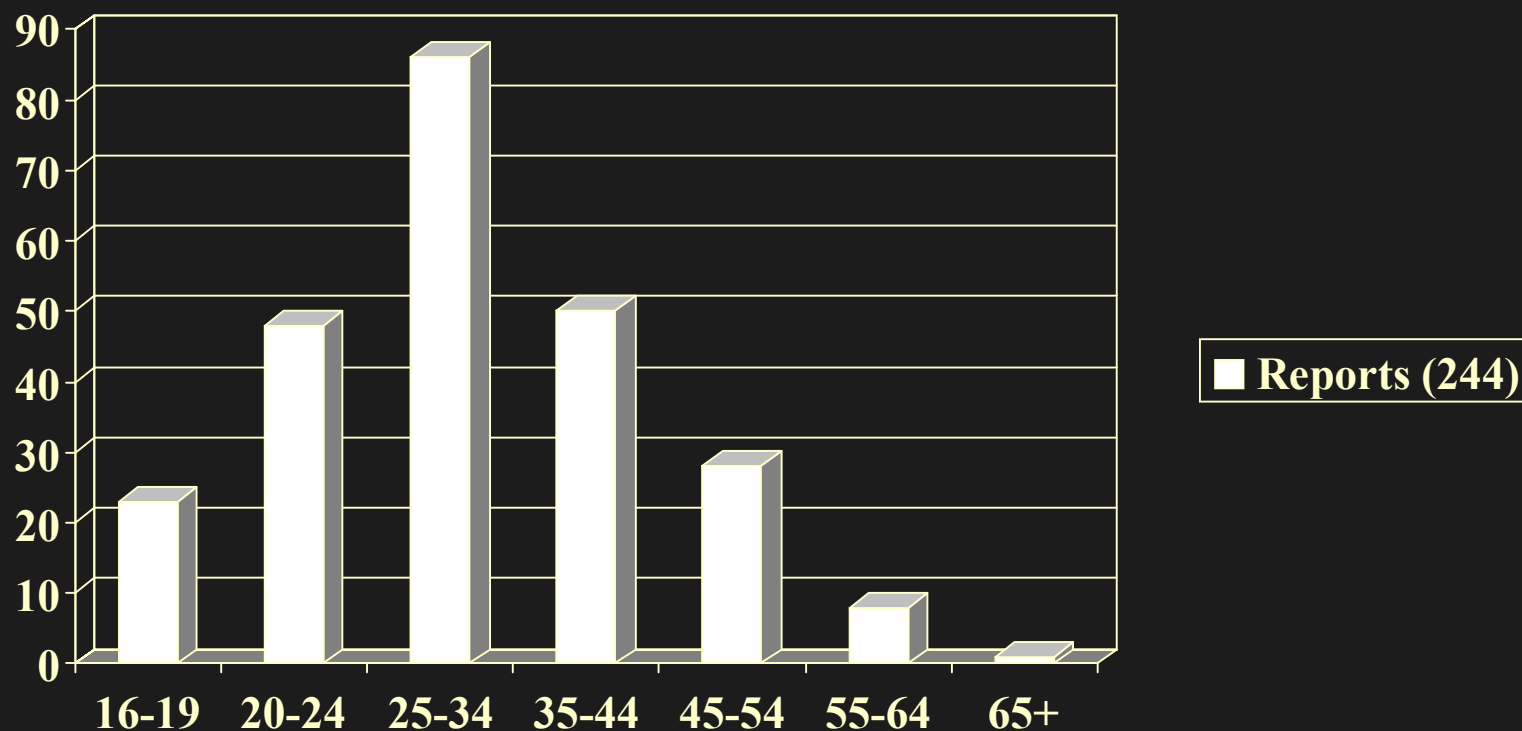
Ref: NIOSH. Worker Death by Electrocution: A Summary of NIOSH Surveillance and Investigative Findings, 1998, Figures 9 and 10, p. 17

Electrocution Fatalities By FACE By Occupation, 1982-1994



Ref: NIOSH. Worker Death by Electrocution: A Summary of NIOSH Surveillance and Investigative Findings, 1998, Figure 7, p. 15

Electrocution Fatalities By FACE By Age 1982-1994

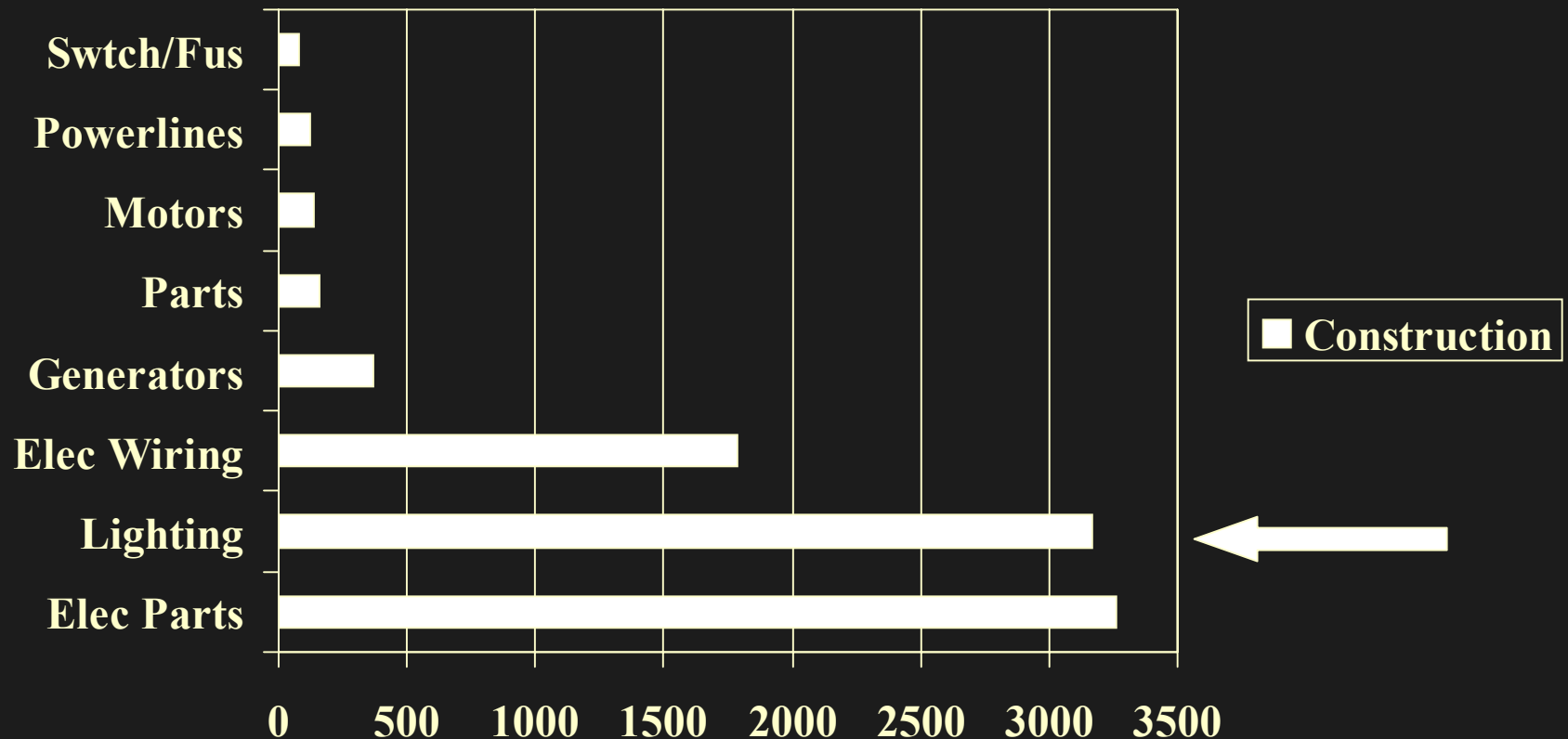


Ref: NIOSH. Worker Death by Electrocution: A Summary of NIOSH Surveillance and Investigative Findings, 1998, Figure 5, p. 14

Electrical Injuries Statistics

1999 US BLS Construction Data

For 9,265 Reported Lost Work Day Cases



French Utility (EDF) Data (Cabanes, 1992)

- Ten year data for 120,000 employees
- Accident rate of 125/year electrical injuries
- 1231 Total/10 year study
- 2.4% Fatalities
- 77% Electrical arc injuries
- 21% Permanent disability

Heinrich's Triangle

Ref: IEEE IAS Magazine, 2000
May/June, p. 18



Methods

Incident Surveillance Goals

- Identify occupational electrical fatalities or fatalities in part due to work on or near an energized source.
- Identify occupational electrical injuries or injuries in part due to work on or near an energized source.
- Identify occupational incidents with the potential for creating a fatality or injury scenario involving electricity.

Uses of Incident Surveillance

- Measure the burden of incidents.
- Guide people and partners to specific corrective actions to reduce incidents.
- Detect changes and their effects.
- Monitor trends.

Definitions

- **Injury**

“...defined as the transfer of energy to human tissues in amounts and rates that damage cellular structure, tissues, blood vessels, and other bodily structures.”

Ref: Christoffel T, Gallagher SS. Injury Prevention and Public Health.
Gaithersburg: Aspen Publishers, 1999. p. 27

Definitions

- **Electrical Injury Case Definition**
 - Unintentional injury that has resulted from electrical, thermal, acoustic, and radiation exposures released at the moment of an electrical incident
 - Mechanical contact with an electrical source may have occurred, but is not necessary
 - Significant skin wounds may be present, but are not necessary
 - Loss of consciousness may have occurred but is not necessary
 - CPR may have been required, but is not necessary

Definitions

- **Electrical Incident**

“An electrical incident is an event resulting from either personnel action or equipment failure involving electrical installations that have the *potential* to result in an injury due to

1. Electrical flash and/or burn;
2. Electrical shock from a source greater than 50V; or
3. Reflex action to an electric shock.”

Ref: Capelli-Schellpfeffer M, Ligget D, et al. How we can better learn from electrical accidents. IEEE IAS Magazine, May/June 2000, p. 17

Definitions

- **Electrical Hazard**

“A dangerous condition such that contact or equipment failure can result in electric shock, arc flash burn, thermal burn, or blast.”

Ref: NFPA 70E Standard for Electrical Safety Requirements for Employee Workplaces 2000 Edition, p. 70E-8

Definitions

- **Shock Hazard**

“A dangerous condition associated with the possible release of energy caused by contact or approach live parts.”

Ref: NFPA 70E Standard for Electrical Safety Requirements for Employee Workplaces 2000 Edition, p. 70E-11

Definitions

- **Electrocution**

“The taking of life by passage of electric current through the body.”

Ref: Dorland's Illustrated Medical Dictionary, New York: Saunders, 24th Edition, p. 472

Definitions

- **Electrocute**

“...to administer a fatal electric shock to”

Ref: New Lexicon Webster's Dictionary, New York: Lexicon Publications, Inc., 1989, p. 303

Definitions

- **Electroshock therapy**

“...therapy using an electric current...”

Ref: New Lexicon Webster's Dictionary, New York: Lexicon Publications, Inc., 1989, p. 304

Surveillance Serves Prevention

- Primary: Reducing all incidents
- Secondary: Mitigating injury/fatality
- Tertiary: Advancing rehabilitation

Questions To Assist Care and Guide Incident Prevention

- 1. Where and when?
- 2. What was the victim doing?
- 3. Direct electrical contact?
- 4. What was exposure duration?
- 5. Did the victim fall?
- 6. What was worn (PPE)?
- 7. Were others involved?
- 8. Voltage, current capacity & source?

Ref: Capelli-Schellpfeffer M, Lee RC, et al. Correlation between electrical accident parameters and injury. IEEE IAS Magazine May/June 1997.

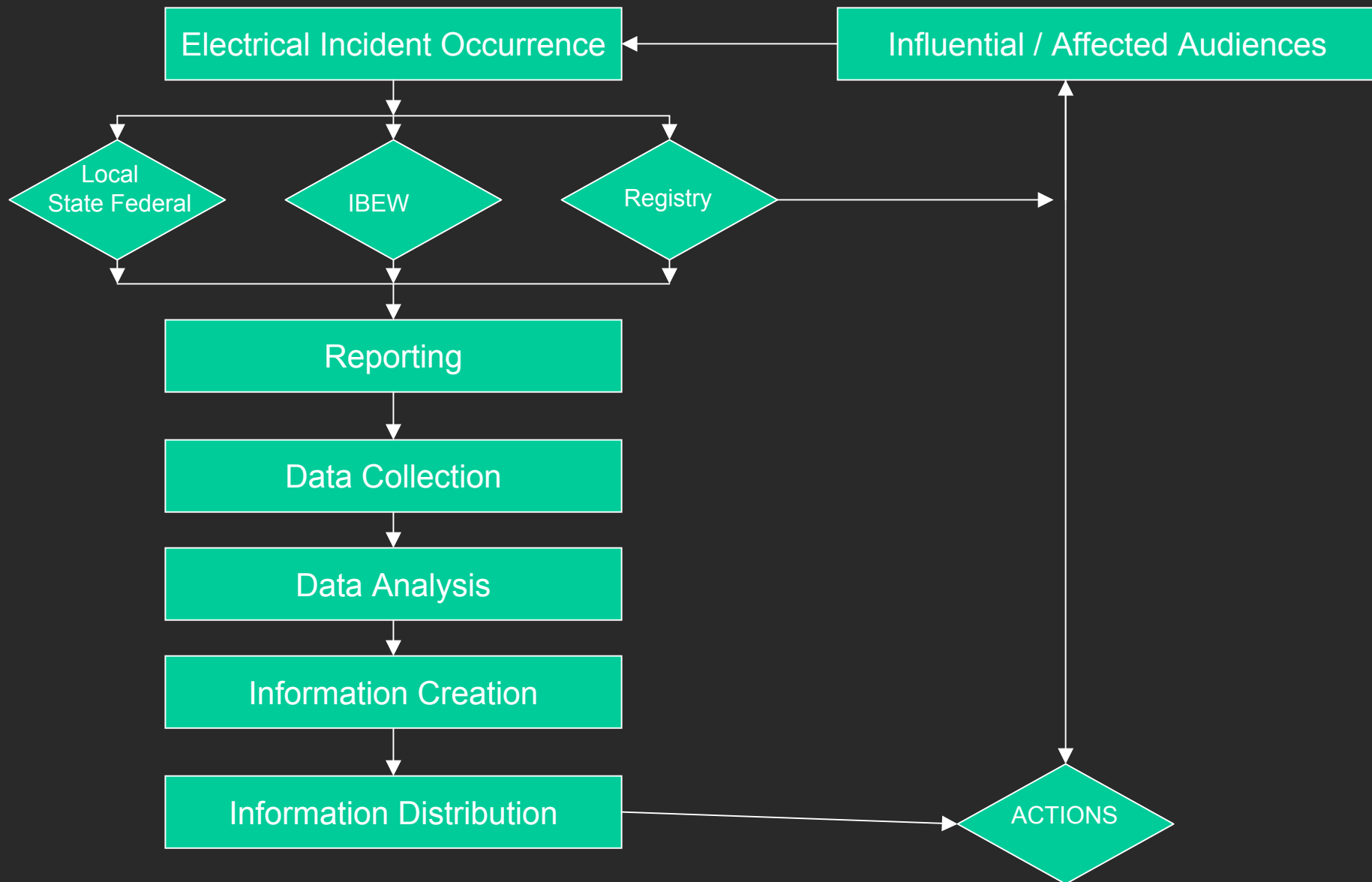
Questions, continued

- 9. Was hazard recognized?
- 10. LOC, confusion or disorientation?
- 11. CPR done?
- 12. Cervical collar or splints used?
- 13. Explosion?
- 14. Closed space?
- 15. Other hazards?
- 16. Who has more info?

Ref: Capelli-Schellpfeffer M, Lee RC, et al. Correlation between electrical accident parameters and injury. IEEE IAS Magazine May/June 1997.

Data Collection, Templates and Recent Analysis

Incident Data Collection Flowchart



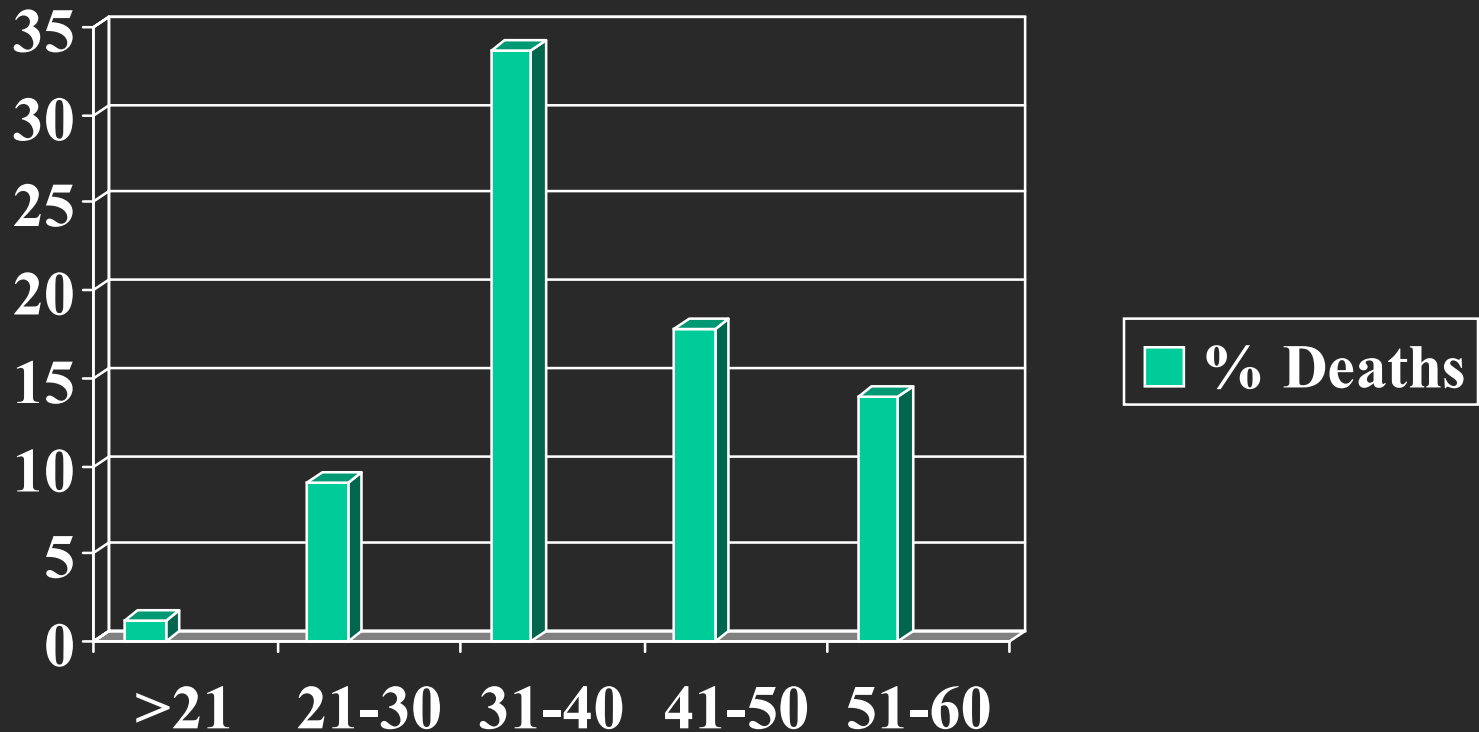
IBEW Data

- Data collection began in 1970s
- Reports periodically compiled into survey volume and distributed regionally
- Release dates: 1975, 1978, 1980, 1982, 1986, 1988
- Transmission and Distribution Worker Fatalities reported for 1971-1987

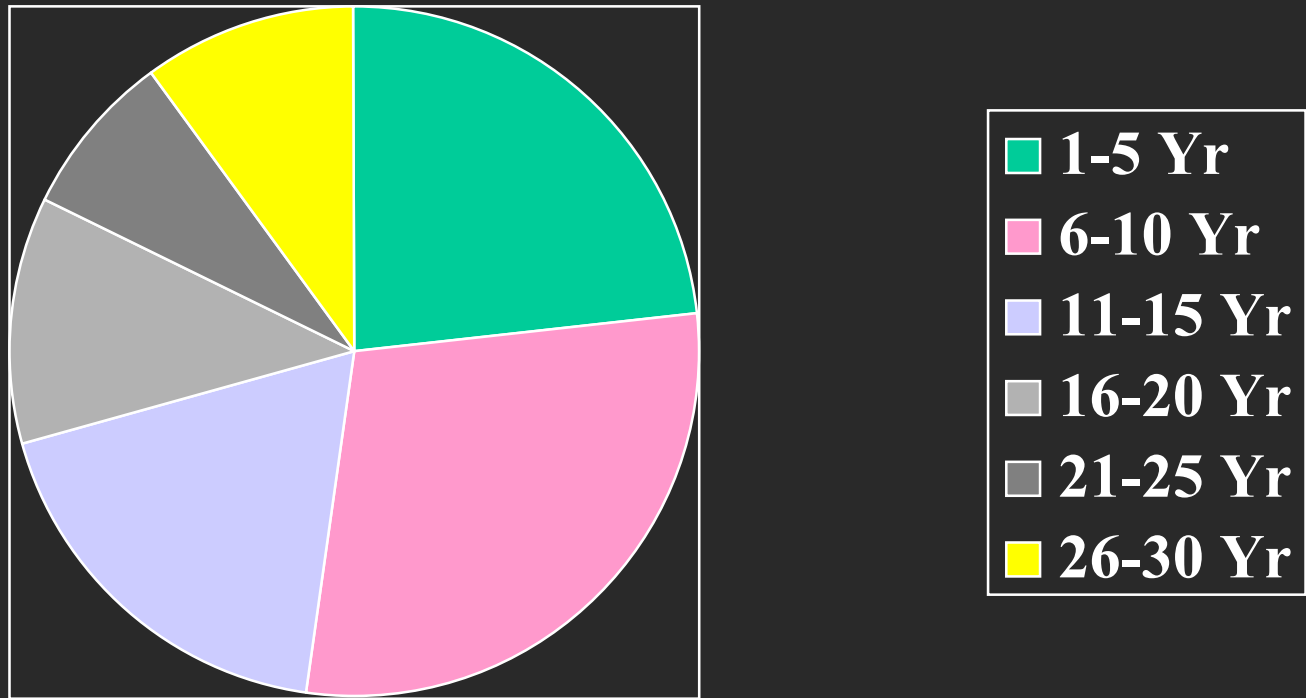
IBEW T & D Data

- During the study period, average IBEW membership size was 905,000 / yr
- T & D members average 55,000 / yr
- While T & D members made up 6 % of total membership during study period, fatalities in this IBEW group accounted for 50%.

IBEW 1975 - 1988 Fatality Data By Age Brackets



IBEW 1975 - 1988 Fatality Data By Seniority Brackets



Fax Anonymous Registry

FAR Project

- Fax to widen participation
- Anonymity to enhance reporting and counter-balance disincentives
- Registry to archive experience

Template Sections

When did the electrical incident occur?

YEAR_____ MONTH_____

Day of week:

_____ Unknown
_____ Monday
_____ Tuesday
_____ Wednesday
_____ Thursday
_____ Friday
_____ Saturday
_____ Sunday

Time of day:

_____ Unknown
_____ Daylight
_____ Dusk
_____ Dark
_____ Dawn

Template Sections, cont'd.

Was someone killed at the scene of this electrical incident?

- ☐ Unknown.
- ☐ No.
- ☐ Waiting for medical information.
- ☐ Yes. How many people were killed? _____

Was someone injured at the scene of this electrical incident?

- ☐ Unknown.
- ☐ No.
- ☐ Waiting for medical information.
- ☐ Yes. How many people were injured? _____

If people were injured, please describe or check all that apply.

- ☐ Only first aid required at the incident scene
- ☐ First aid/emergency room care was required.
- ☐ Hospital admission was required for one or more.

What Kinds of problems did people report?

- | | |
|---|--|
| <input type="checkbox"/> Burns | <input type="checkbox"/> Other. Please |
| <input type="checkbox"/> Blast injury | explain: |
| <input type="checkbox"/> Brain injury | |
| <input type="checkbox"/> Crush injury | |
| <input type="checkbox"/> Fall injury | |
| <input type="checkbox"/> Nerve injury | |
| <input type="checkbox"/> Stomach injury | |

Template Sections, cont'd.

What was the voltage of the electrical source?

_____ Volts
_____ Unknown

What was the current of the electrical source?

_____ Amperes
_____ Unknown

Template Sections, cont'd.

At what kind of location did the electrical incident occur?

- ☐ Unknown
- ☐ Boating
- ☐ Construction
- ☐ Demolition
- ☐ Farm
- ☐ Home
- ☐ Manufacturing
- ☐ Military
- ☐ Mining
- ☐ Park
- ☐ Plant
- ☐ Public Building
- ☐ Outdoors/Home Yard
- ☐ Recreation Area
- ☐ Renovation
- ☐ School
- ☐ Other. Please explain:

Template Sections, cont'd.

Was a person present at the electrical incident?

_____ Unknown

_____ No.

_____ Yes, the incident was attended.

If yes, how many were present?

_____ 1

_____ 2

_____ 3

_____ 4

_____ 5

_____ More than 5

Template Sections, cont'd.

What kind of electrical source was involved in the electrical incident?
(Please check all that might apply.)

- ☐ Unknown
- ☐ Static
- ☐ Grounding
- ☐ Overhead power line
- ☐ Underground power line
- ☐ Water over power line
- ☐ Water under power line
- ☐ Water near electrical power tool or equipment
- ☐ Motor control center
- ☐ Control equipment
- ☐ Switchgear
- ☐ Heat trace
- ☐ Portable equipment
- ☐ Lighting
- ☐ Welding
- ☐ Cable tray
- ☐ Drives
- ☐ Motors
- ☐ Plug in buss duct
- ☐ Other. Please explain:

Template Sections, cont'd.

What kinds of jobs were being done?
(Please check all that apply.)

- ☐ Unknown
- ☐ Design
- ☐ Electrician
- ☐ Engineer
- ☐ Equipment Operator
- ☐ Heating & Ventilation
- ☐ Home repair
- ☐ Instrument & Electronics Technician
- ☐ Laborer
- ☐ Machinist
- ☐ Maintenance
- ☐ Plant Operator
- ☐ Pipefitter
- ☐ Thermography
- ☐ Architectural
- ☐ Civil Engineering
- ☐ Other. Please explain:

Template Sections, cont'd.

What was the status of those present?

_____ No one was present.

_____ Unknown

_____ Employees of the location

_____ Contractors at the location

_____ Other. Please explain:

Template Sections, cont'd.

What kinds of hazards were present at the incident?
(Please check all that apply.)

- ☐ Unknown
- ☐ Arc
- ☐ Confined space
- ☐ Electrical shock
- ☐ Explosion
- ☐ Falls or work at heights
- ☐ Fire
- ☐ Flash
- ☐ Operating or moving equipment
- ☐ Other. Please explain:

Template Sections, cont'd.

At what kind of location did the electrical incident occur?

- ☐ Unknown
- ☐ Boating
- ☐ Construction
- ☐ Demolition
- ☐ Farm
- ☐ Home
- ☐ Manufacturing
- ☐ Military
- ☐ Mining
- ☐ Park
- ☐ Plant
- ☐ Public Building
- ☐ Outdoors/Home Yard
- ☐ Recreation Area
- ☐ Renovation
- ☐ School
- ☐ Other. Please explain:

Analysis

- Fax Anonymous Registry (FAR) Project for Electrical Incidents evolved from corporate alliance to promote electrical incident reporting.
- Template modified from E. I. DuPont de Nemours Company experience piloted and implemented 1991-2000.
- Analysis Ref: Liggett D, Floyd HL, et al. How Can We Better Learn. IEEE PPIC Safety Tutorial, Portland, June, 2001.

Data

- 886 shared incidents 1991-2000
- 111 electrical shocks reported
- 158 arc flashes
- 36 injuries (4% of Incidents)
 - 12 electrical shock
 - 20 arc flash
 - 4 other

Electrical Incident Data Description, 1992-2000

- **Arcing Events**

805 incidents

236 w/ arc fault 30% incidents

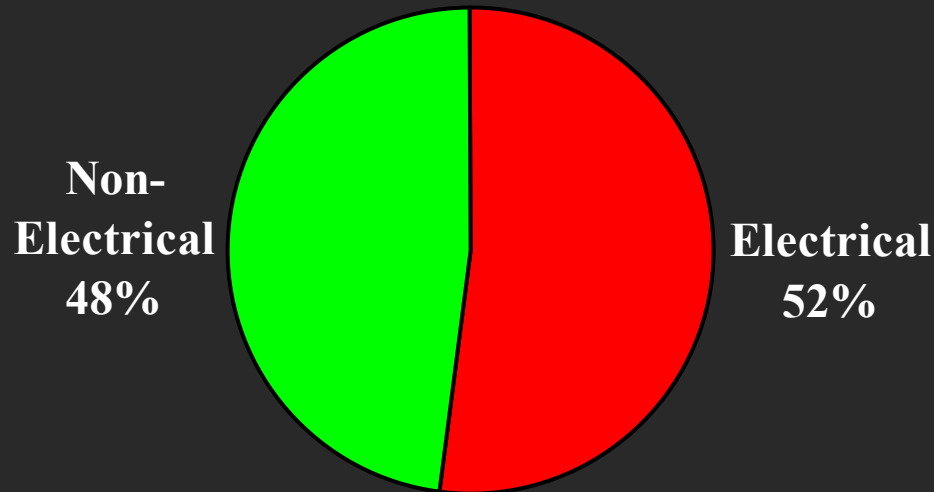
158 arc flashes 20% incidents

97 people exposed 61% of arc flashes

18 injuries 19% exposed people

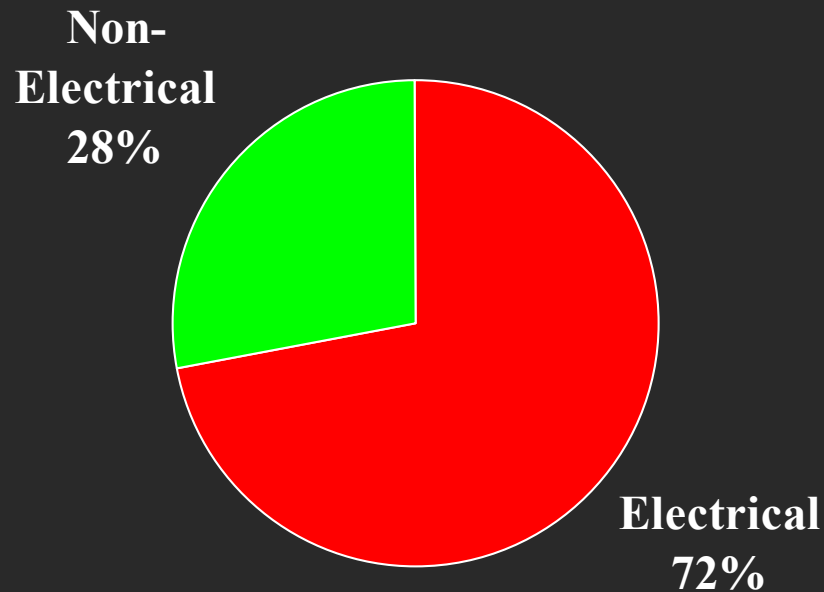
Data Description

- **Who is involved?**
 - It is not only electricians



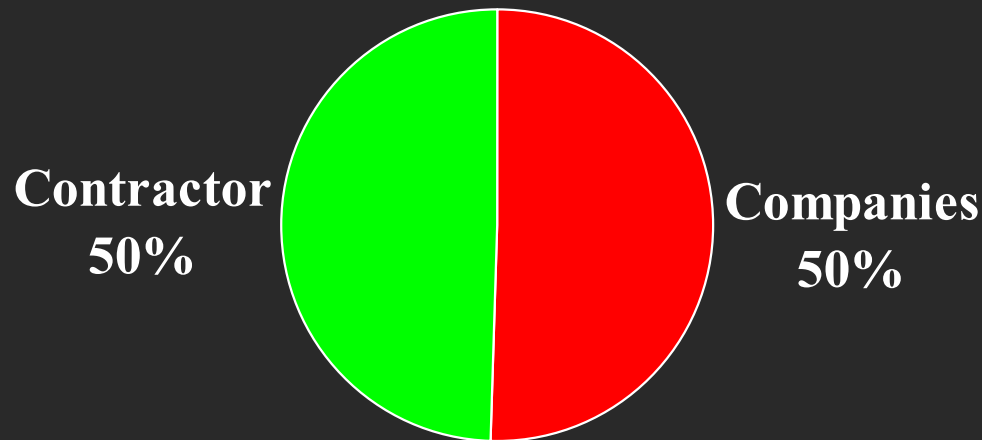
Data Description, cont'd.

- **Who is injured?**
 - **Not only electricians**



Data Description, cont'd.

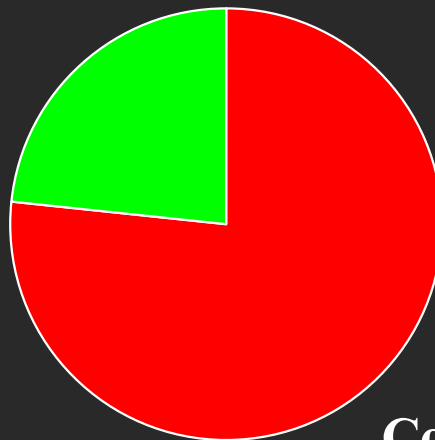
- **Who employs exposed workers?**
 - **Not only contractors**



Data Description, cont'd.

- **Who do the injured work for?**
 - **Not only contractors**

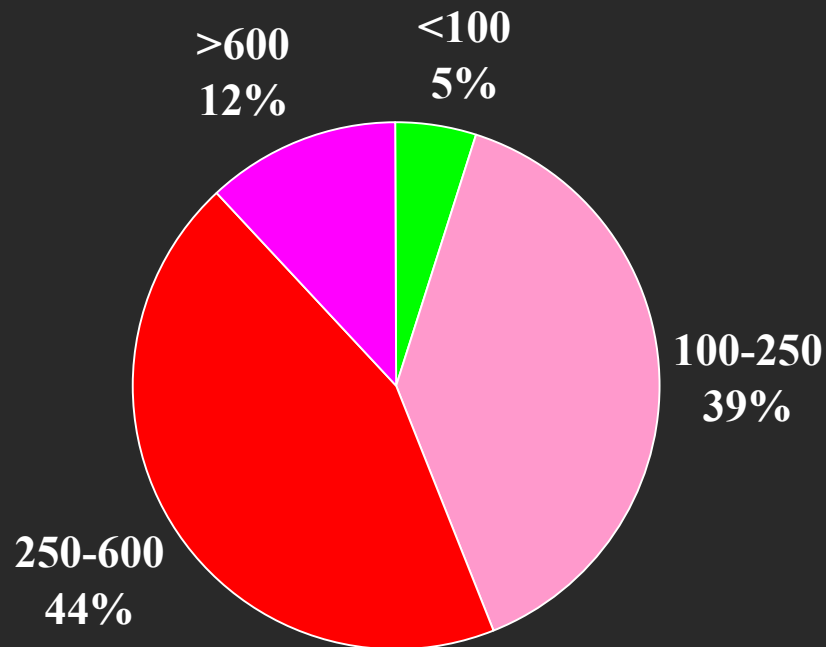
Contractor
23%



Companies
77%

Data Description, cont'd.

- What voltages are involved?
 - Not only power line voltages



Electrical Incident Chart

Control equipment – a

Motor control centers – b

Lighting – c

Other – d

Switchgear – e

Portable equipment – f

Overhead lines – g

Cable trays – h

Underground – i

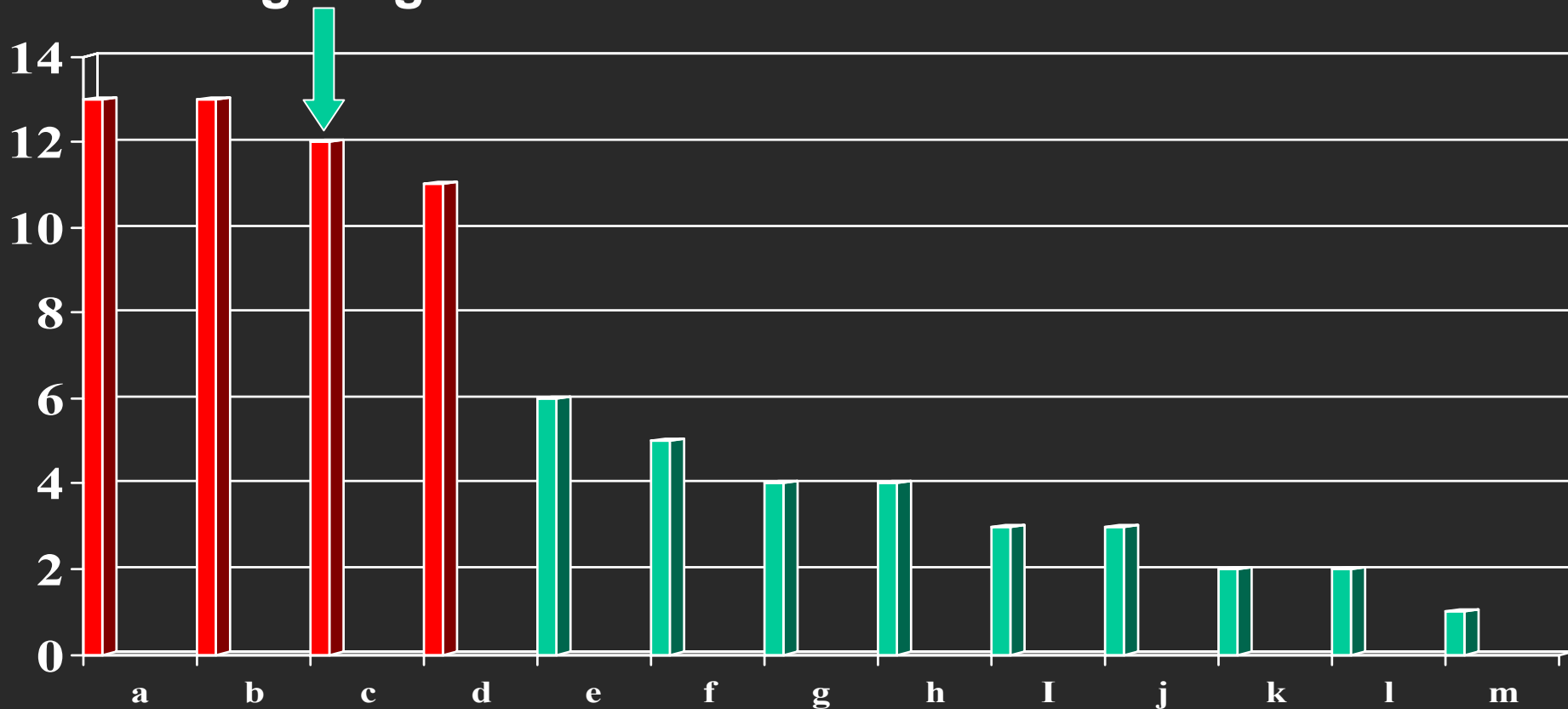
D & R – j

- Lockout/tagout – k
- Heat trace – l
- Motors – m
- Not illustrated due to few occurrences:
 - Drives – n
 - Welding – o
 - Water – p
 - Grounding – q
 - Static – r
 - Plug in buss - s

Electrical Incident Data

Equipment involved is not only switchgear.

Lighting



Key Insights

From *To Engineer Is Human*, 1985

Henry Petroski

The human advantage...

“is the ability

to learn

from experience.”

Multi-Hazard Events in Multi-Process Environment



Lighting Incidents

- Lighting tasks are common in injury and fatality incidents.
- Lighting-related work in construction is a common activity in electrical lost time cases.
- Voltages supplying lighting are a common in fatalities.

Incidents + Deaths

- Always reported
- Acutely recognized
- Action results

Incidents w/ or w/o injuries

- Dis-incentives to reporting
- Coding cases
- Acute and chronic consequences
- Less actionable

Closing

“...every electrical accident is a potential fatality except for some serendipitous set of circumstances that combines to prevent the victim's death.”

Ref: Cawley JC. Electrical accidents in the mining industry, 1990 – 1999. In the Proceedings of the IEEE IAS Annual Conference, Chicago, 2001.